

WHAT IS CLAIMED IS:

- 1        1.        A punching apparatus, comprising:  
2                a male die, adapted to be opposed to a first face of a metallic plate  
3 member, the male die including a plurality of punches which are provided on  
4 the male die and arranged side by side in a first direction with a fixed pitch; and  
5                a guide member, formed with a guide face which supports a side  
6 portion of the male die, at least when the punches are pressed into the plate  
7 member in a second direction, to form through holes therein.
  
- 1        2.        The punching apparatus as set forth in claim 1, wherein the side  
2 portion of the male die extends in parallel with the first direction.
  
- 1        3.        The punching apparatus as set forth in claim 1, wherein the punches  
2 are arranged on a base member which is actuated so as to collectively press  
3 the punches into the plate member.
  
- 1        4.        The punching apparatus as set forth in claim 1, wherein:  
2                each of the punches has a polygonal cross section including two  
3 sides which are parallel to the first direction; and  
4                side faces of each of the punches corresponding to the two sides are  
5 supported by the guide member.
  
- 1        5.        The punching apparatus as set forth in claim 4, wherein the guide  
2 member is formed with projections which support at least one side face of each

3 of the punches which faces a gap defined between adjacent punches.

1 6. The punching apparatus as set forth in claim 5, wherein the  
2 projections are arranged such that two adjacent punches are placed between  
3 two adjacent projections.

1 7. The punching apparatus as set forth in claim 6, wherein the  
2 projections are arranged such that at least one projection is placed between a  
3 gap defined between the two adjacent punches.

1 8. The punching apparatus as set forth in claim 5, wherein the guide  
2 face and the projections are formed by grinding work.

1 9. The punching apparatus as set forth in claim 4, wherein each of the  
2 punches has a rectangular cross section.

1 10. The punching apparatus as set forth in claim 1, wherein the male die  
2 includes a first die for forming unpenetrated holes in the first face of the plate  
3 member, and a second die for punching the unpenetrated holes to form  
4 through holes communicated with a second face of the plate member which is  
5 opposite to the first face.

1 11. The punching apparatus as set forth in claim 1, wherein the fixed  
2 pitch is 0.3 mm or less.

1 12. The punching apparatus as set forth in claim 1, wherein a width of the  
2 hole is 0.2 mm or less.

1 13. The punching apparatus as set forth in claim 10, wherein a ratio of a  
2 distance between the first face and the second face with respect to a width of  
3 the hole is 0.5 or more.

1 14. The punching apparatus as set forth in claim 1, wherein the first face  
2 is a portion of the plate member which has been subjected to a plastic working.

1 15. The punching apparatus as set forth in claim 14, wherein the portion  
2 is a bottom face of a recess.

1 16. The punching apparatus as set forth in claim 1, wherein the punches  
2 are adapted to be pressed into the plate member comprised of nickel.

1 17. A plate member manufactured by the punching apparatus as set forth  
2 in claim 15.

1 18. A liquid ejection head incorporating the plate member as set forth in  
2 claim 17, comprising:

3 a sealing plate, joined to the plate member so as to seal the recess to  
4 form a pressure generating chamber; and

5 a metallic nozzle plate, formed with a plurality of nozzles and joined to  
6 the plate member such that each of the nozzles is communicated with

7 associated one of the through hole,

8 wherein liquid droplets are ejected from the nozzles by pressure  
9 fluctuation generated in liquid contained in the pressure generating chamber.

1 19. The punching apparatus as set forth in claim 1, wherein the guide  
2 member is arranged movably in the second direction.

1 20. The punching apparatus as set forth in claim 19, wherein:  
2 the guide member is formed with a first face, a second face, and a  
3 through hole which communicates the first face and the second face;  
4 the male die is inserted from an opening of the through hole at the first  
5 face, and allowed to move therein in the second direction; and  
6 an inner face of the through hole serves as the guide face.

1 21. The punching apparatus as set forth in claim 20, wherein the second  
2 face of the guide member is brought into contact with the plate member, so  
3 that the punches are projected from an opening of the through hole at the  
4 second face when the through holes are formed.

1 22. The punching apparatus as set forth in claim 21, wherein the guide  
2 member is arranged such that distal end face of the punches and the second  
3 face of the guide member are made flush with each other, before the second  
4 face is brought into contact with the plate member.

1 23. The punching apparatus as set forth in claim 15, wherein the bottom  
2 face is a slope face.

1 24. The punching apparatus as set forth in claim 3, further comprising a  
2 fixation member, to which the male die is fixed, wherein:

3 the base member includes a first part integrated with the punches,  
4 and a second part continued from the first part and fixed at the fixation  
5 member;

6 the first part has a higher rigidity than a rigidity of the punches and a  
7 first cross sectional area in parallel with the first direction which is larger than a  
8 total cross sectional area in parallel with the first direction of the punches; and

9 the second part has a second cross sectional area in parallel with the  
10 first direction which is larger than the first cross sectional area.

1 25. The punching apparatus as set forth in claim 24, wherein the guide  
2 member supports the first part of the base member.

1 26. The punching apparatus as set forth in claim 24, wherein the fixation  
2 member is formed with a retainer which restricts a movement of the second  
3 part of the base member in the second direction.